EFFECT OF SPACINGS AND STAKING ON GROWTH AND YIELD OF WINGED BEAN

(*Psophocarpus tetragonolobus* (L.) D.C.)

THESIS

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By
SUJEET KUMAR LODH

DEPARTMENT OF HORTICULTURE
JAWAHARLAL NEHRU KRISHI VISHWA VIDYALAYA
COLLEGE OF AGRICULTURE
JABALPUR, M. P.

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CERTIFICATE - I

This is to certify that the thesis entitled "Effect of spacings and staking on growth and yield of winged bean (*Psophocarpus tetragonolobus* (L.) D.C.)" submitted in partial fulfilment of the requirements for the degree of Master of Science in Agriculture (Horticulture) of the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of the bonafide research work carried out by Shri Sujeet Kumar Lodh under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma. All the assistance and help received during the course of the investigations have been duly acknowledged by him.

Chairman of the Advisory Committee

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

Chairman	(Shri D.A. Sarnaik)
Member	(Dr. K. Singh)
Member	(Dr. S.K. Shrivastava)
Member	(Dr. Lalchand)
Member	(Shri R.S. Sharma)
Member	(Shri Arvind Mishra)

C E R T I F I C A T E - II

This is to certify that the thesis entitled "Effect of spacings and staking on growth and yield of winged bean (*Psophocarpus tetragonolobus* (L.) D.C.)" submitted by Shri Sujeet Kumar Lodh to the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, in partial fulfilment of the requirements for the degree of M.Sc.(Ag.) in the Department of Horticulture has been approved by the Student's Advisory Committee and External Examiner after an oral examination on the same.

P. S. Pausari
External Examiner

Major Advisor

Head of the Department

Director of Instructions
17.7.88

A C K N O W L E D G E M E N T S

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Jabalpur,

Dated: 16-5-1984

(SUJEET KUMAR LODH)

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CHAPTER - I

INTRODUCTION

Winged bean (Psophocarpus tetragonolobus (L.) D.C.) is a newly introduced leguminous vegetable crop. It was introduced in India in 1799 at the Botanical garden, Sibpur, Calcutta (Chandel et al., 1979) and presently, it is cultivated in scattered pockets in the states of Goa, Maharashtra, Karnataka, Tamil Nadu, Kerala, Madhya Pradesh and Bengal. It is called "Goa bean" in Goa, Chopati sem in Maharashtra, Rahhi avarai or"Kuttu avarai" in Karnaraka, Boondi avarai or Parandhi avarai in Tamil Nadu, "Choughla or Choudhary sem" in Madhya Pradesh and Charpatti sem in Bengal.

This requires warm humid and sub-tropical climate. High rainfall with its well distribution during entire growing season is preferable to this crop. Sandy loam soils rich in organic matter or clay-loam soils with efficient drainage are good for its cultivation. It does not thrive well in heavy alkaline soils as well as in water logged conditions.

Winged bean is a vigorous growing herbaceous climber. It is a hardy annual immune to pests and diseases. It is also a prolific yielder (Nanjunda Reddy, 1982). Its leaves are trifoliate, the flowers are of papilionaceous type and blue or white in colour (Agcaoili, 1906).

It's pod may be of 4 to 12" in length which have four sided corners.

There are 10 to 16 seeds per pod (Tindall, 1968). The shape of the seeds varies from nearly globular to almost conical. Their colour may be white, yellow, brown or black. The roots become thickened and tuberous and are edible. This is the most heavily nodulated leguminous crop. Winged bean is such a vegetable of which almost all parts (leaf, young shoot, flower pod, seed and tuber) are consumed as a vegetable. It has very high protein contents (29.8 to 41.7%) which is comparatively much superior than all other vegetable crops. Thus it play very important role in vegetarian human diet of Indians. It is not only important for human diet but also improve the physical properties of soil and left sufficient residual nitrogen for succeeding crop.

Among the other major commercially important legumes winged bean is a lesser known tropical legume, lacking adequate scientific information, its full potentialities have yet to be discovered (Anonymous, 1975). Several investigations on legumes in India and abroad indicated the necessity of staking. In Burma, winged bean is grown in non-staked field, (Prain, 1903 and Dillard,1977).

In India, winged bean is being staked with bamboo sticks in scattered pockets in the states of Goa. The experimental evidence has shown that by increasing the growth of winged bean through staking and wider spacing yield can be increased up to limited extent. Keeping in view, the above points and to provide valuable information for package of practices of winged bean, the present experiment, entitled "effect of spacing and staking on growth and yield of winged bean (*Psophocarpus tetragonolobus* (L.) D.C.) was carried out in 1983-84 with the following objectives.

(1) To find out the optimum spacing for maximization of yield.

(2) To find out the effect of staking on growth and yield.

(3) To find out the suitable combination of spacing and staking for increasing the yield.

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CHAPTER - II

REVIEW OF LITERATURE

Growth and yield of crop are governed by several factors, plant nutrition constitutes one of the most important factors which determines the yield and quality of the vegetables. Literature on the response of spacing, staking and their combinations on winged bean (Psophocarpus tetragonolobus) (L.) D.C.) is limited and hence a review of literature on the work done on similar lines on related genera and species such as French bean (Phaseolus vulgaris) Cowpea (Vigna unguiculata) and Soybean (Glycine max. (L.) Merrill.) etc is being given on different aspects of plant growth and development.

Effect of spacing:

Optimum plant population per unit area is one of the most important cultural manipulation for increasing the productivity of any crop. Plant population can be increased or decreased by decreasing or increasing of spacing. Though individual plant of wide spaced crop has superior yield attribute, it could not be able to produce higher yield per unit area than closer planted crop due to less plant population. Hence, the studies regarding plant spacing is of greater importance.

Lenka (1966) found a gradual reduction in the numbers of leaves per plant as row spacing was brought close in pea crop.

Weber *et al.* (1966) reported that plant population arrangement (i.e. high plant populations and narrow row spacing) in soybean favours a rapid attainment of high LAI (Leaf Area Index). They also reported that plants at lower densities give more seed yield.

Gritton and Eastin (1967) reported that the yield of soybean generally increased with increased population. Similar results were reported by Lochaivakul *et al.* (1971), Lawn *et al.* (1977), Lueschen and Hicks (1977), Loomis *et al.* (1971) observed that in dense plant population, reproduction may be suppressed, principally because of the amount of photosynthate per plant becomes to be limiting even-though carbon assimilation per unit ground area may be high and there by reduce the yield in soybean.

Mishra and Singh (1972) observed that when the spacing was increased, the number of pods per plant were decreased in soybean.

Enyi (1973) reported that grain yield of soybean per hectare decreased by 38, 51 and 72 percent respectively with increase in plant population from 74 to 111, 222, 444 thousand plants per hectare, total dry matter per hectare significantly increased with increase in plant population. Total dry matter per plant, number of pods per plant decreased with increase in plant population.

Ezodinma (1974) reported that the close spacing between and within rows significantly increased the yield of cowpea.

Veeraswamy and Rathnaswamy (1974) observed that wider spacing increased the number of pods as well as grain yield per plant in soybean.

Pandey et al. (1974) reported that the green pod yield per plant and total yield per hectare was highest at wider spacing of 60 cm. in Phaseolus vulgaris.

Enyi (1975) found increased LAI with increase in plant density in kidney bean.

Reddy and Singh (1976) found that the LAI of soybean was decreased with the decrease in plant population but the effect of row spacing was not significant. They also observed that number of pods per plant and seed weight decreased significantly with increase in plant population.

Erskine and Khan (1977) observed that pods per plant was decreased with the increase in plant population in cowpea.

Bennett et al. (1977) observed that racemes per node and branches/plant were significantly increased by higher density. He had also concluded that a bean ideotype for temperate zone monoculture should have a high number of nodes/branch and 3 to 5 branches/plant in bean.

Goulden (1977) reported that the yield per hectare of navy beans was generally increased with increasing plant densities but the number of seeds per pod and 100 seed weight were not affected.

Pant and Joshi (1977) reported that when crop density of soybean was increased there was decrease in number of pods per plant, number of seeds per pod and 1,000 seed weight.

Rojas _et al_. (1977) reported that when plant spacing is increased, the number of pods per plant increased but the number of pods per unit area decreased. They also found that spacing had no significant effect on the number of seed per pod and on seed weight in beans crop.

Subramanium _et al_. (1977) recorded the maximum number of pods (16.6) per plant and thus, contributing to the highest yield of 1824 kg. of grain per hectare in close spacing (50 x 10 cm).

Badillo _et al_. (1978) reported that pod number and pod weight were highest with the widest planting distance in _Phaseolus vulgaris_.

Patel _et al_. (1978) reported that the yield of soybean was significantly influenced by spacing.

Mohdnoor (1980) observed that there was an increasing trend in dry seed yield as the plant density increased from 67,000 to 2,00,000 plants per hectare. This increase was essentially linear indicating that dry seed yield of cowpea could be increased further by increasing the plant density.

Rajendran (1978) reported that seeds of winged bean were sown 10 to 15 cm apart in rows which were 50 cm apart from each other to accommodate 1, 50, 100 plants per hectare for economical yield. He also reported that this crop produces about 15 to 20 quintals of seeds or 15 to 19 tonnes of green pod and the tuber yield reaches up to 4 tonnes.

Chandel _et al_. (1979) reported that spacing of 60 x 45 cm is required for winged bean. Green pod 2.5 kg, 380 gm seed and 1065 gm tuber yield per plant have been recorded at Amravati station (N.B.P.G.R., 1978).

Bhaskar Rao (1981) reported that filling percentage and average pod weight were not affected significantly due to spacings.

Nanjunda Reddy (1982) reported the spacings of 100 x 20 cm for winged bean. He also observed 20 tonnes green pod yield per hectare and 2.5 tonnes seed yield per hectare of winged bean if grown only for seed.

Effect of staking on growth and yield:

Cervato (1958) obtained highest total yield by the caseletta system, in which the plants were staked individually and the stakes tied. When staking was entirely omitted the yield was slightly lower. Upright stakes with two horizontal wires/ row gave significantly lower yields than either of the above system in Tomato (Lycopersicon esculentum Mill.).

Anonymous (1961) observed that three pairs of parallel wires at 1, 2½ and 4 ft above the ground were suitable for cluster as well as strong growing types in tomato crop.

Denby (1964) reported that for early production under the short season, conditions bush determinate variety, summer down was more profitable than the indeterminate (vine) types when these were grown either staked or without support in tomato variety.

Casarini and Silvestri (1966) reported that with horizontal wire support the planting density for the four tomato varieties tested was much greater than without support, but in the unsupported crops, the yield was slightly lower. Fruit size was not affected by the presence or absence of supports. Support reduced the incidence of cracking and post harvest breakdown and raised the percentage of normal fruit.

Dodds and Sencan (1969) reported that the yield, quality and Vitamin 'C' content of the fruit were highest in plots where no staking or pruning had been carried out.

Wurster and Nagange (1971) observed that the variety, money maker consistently out yielded all other varieties in Uganda and Kenya. However, staked plants produced greater quantities or marketable fruit in Uganda. In Kenya, greater yield was obtained from unstaked tomato plants. However, the results obtained in Uganda indicated that when leaf diseases are a limiting factor, yields of marketable fruit are increased by staking.

Dimitrov and Dimov (1969) found that the three stem plant training considerably retarded ripening, the earlyness index falling by 47.9% and also reduced profitability compared to single stem plant training.

Baldy and Ackerl (1973) found that the successful system for growing semi-determinate tomato plants was with three stem on a three wire trellies under plastic.

Ganjeh and Coutillon (1974) noted that the cylindrical cages produced fruit with greater soluble solids content when the cage diameter was 62 cm. than when it was 31 cm. and when the cage height was 62 cm. rather than 31 or 93 cm. Cage size did not, however affect juice pH, fruit colour yield or time required for harvest.

Quinn (1974) showed that under wer conditions marketable yields were significantly increased by staking the tomato crop.

Allington et al. (1975) described several training systems for tomatoes, including the modified guernsey arch way system, jayering system and the dutch hook system.

Adelana (1976) worked on tomato plants of the tall and semi-determinate variety. Ife and determinate variety Pusa Early Dwarf and tied to 1.5 m staked or left unstaked. In both varieties staking increased total dry matter production and LAI, the yield rose by 18 to 25%. Both average fruit weight and number of fruit/plant were increased by staking.

Swingle (1977) worked on tomato training system and reported the results of five years trials. Data were presented on the yields and fruit size of several tomato cultivars supported in cylindrical wire cages. Annual yields of over 40 lb/plant were obtained.

Agwdelo _et al_. (1972) reported that the bean cultivars Diacol Colima (Bush type) and Huasano (semi-climbing) were planted with 333,333,250000, 200.000 or 166.660 plants/has. A plant population of 250,000 gave the best yield in both cultivars. The number of pods/plant was the characteristic, most affected by plant population and fell with rising plant population.

Effect of staking and spacing on growth and yield:

Campbell (1961) observed that neither staking nor pruning increased yields or fruit size or hastened fruiting at a spacing of 3 x 1.5 ft.

Schoppers (1965) worked on tomato training methods and found that training over the pathway could give the best results provided there was sufficient space between plants and glass to allow full air circulation and that shade was available when necessary. Training the shoots up to the guttering space also proved satisfactory.

Deidda (1968) reported that the tomato varieties I-50 269-9, 43 Barbieri and Smarzano Baldoni were grown with and without supports at a density of 2.5 plants/ sq.m in a single row 110 or 150 cm. apart and in double row at alternate distance of 40 and 60 cm. All three varieties showed yield response to staking.

Vogel and Weichold (1969) recommended the spacing of 0.45 cm x 0.35 m for profitable production in staked tomato.

Pinchinat (1974) recommended 100,000 - 400,000 plants per hectare of climbing type red-seeded bean cultivars 400.000 plants/ha.

Kuememan _et al_. (1978) reported that the indeterminate type dry beans were grown in closer within row spacings (5 and 10 cm) and inter row spacings was 50 and 75 cm, with indeterminate type yields were highest on a trellies, at a closest spacings, followed by those grown without support.

Rajewar and Patil (1979) conducted an experiment on spacing, staking and pruning in tomato and variety 512 produced the largest number of flowers followed by 'HS 101'. Variety HS 101 and 512 produced significantly more fruits than variety, Marglobe. The widest spacing (60 cm x 60 cm) produced significantly more fruits/plant than the closest spacing (35 cm x 30 cm). Variety 512 produced highest yield/plant, followed by variety Marglobe. Both these varieties gave significantly more yield/ plant than the unpruned and unstaked plants of variety, Marglobe. In variety, HS 101, the pruned unstaked plants produced significantly more yield/ plant than the unpruned staked ones. Variety, 512 gave highest yield, which was significantly better than that of variety, Marglobe and HS 101 with wider spacing (60 x 60 cm).

Correlation

Janoria and Ali (1967) reported that seeds per pod and 100 seed weight showed positive and significant correlation with seed yield in cowpea.

Singh and Singh (1969) found the grain yield was significantly and positively associated with seeds per pod, pods per plant and 100 seed weight.

Patel (1973) noted that the positive correlation between seed yield and number of pods per plant in cowpea.

Bordia *et al*. (1977) reported that the positive correlation of seed yield with pod number per plant, pod length and seed number per pod in cowpea were significant and

100 seed weight were nonsignificant.

Goulden (1977) reported that the pods per plant and yield per plant were inversely correlated with yield per hectare, in navy beans.

Rojas *et al.* (1977) found the number of pods per unit area was positively correlated with number of seeds per pod.

Singh *et al.* (1977) noted positive and significant association of pods per plant and number of seeds per pod.

Pandey (1981) reported that pods per plant and 100 seed weight were the most important sink parameters, had positive correlation with green pod yield as well as seed yield in cowpea.

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CHAPTER-III

MATERIALS AND METHODS

The present investigation was carried out in the year 1983-84 at Vegetable Research and Instructional Farm, Maharajpur, Department of Horticulture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur.

Topography of the field:

The topography of the field was fairly uniform with slight slope from west to east for drainage.

Previous history of the field:

The following crops were grown during the last four years in the experimental field.

Table 1: Cropping history of the experimental field

S.No.	Year	Kharif crop	Rabi crop
1.	1979-80	Fallow	Pea
2.	1980-81	Fallow	Pea
3.	1981-82	Fallow	Pea
4.	1982-83	Winged bean	-

Soil:

The soil of the field was typical sandy loam with good drainage. In order to assess the nutrient status of the soil, soil samples were taken from 25 cm depth randomly at ten places of the experimental field with auger before laying out of the experiment and it was representative composit sample was made from it. Then analysed in soil testing laboratory, Department of Soil Sciences, JNKVV, Jabalpur and the data of chemical analysis are given in table 2.

Table 2: Chemical analysis of the soil

pH of the soil	Electrical conductivity mmhos/cm	Organic carbon percent	Available nitrogen kg/ha	Available phosphorus kg/ha	Available potash kg/ha
7.3	0.30	0.66	258	8.0	314

Land preparation:

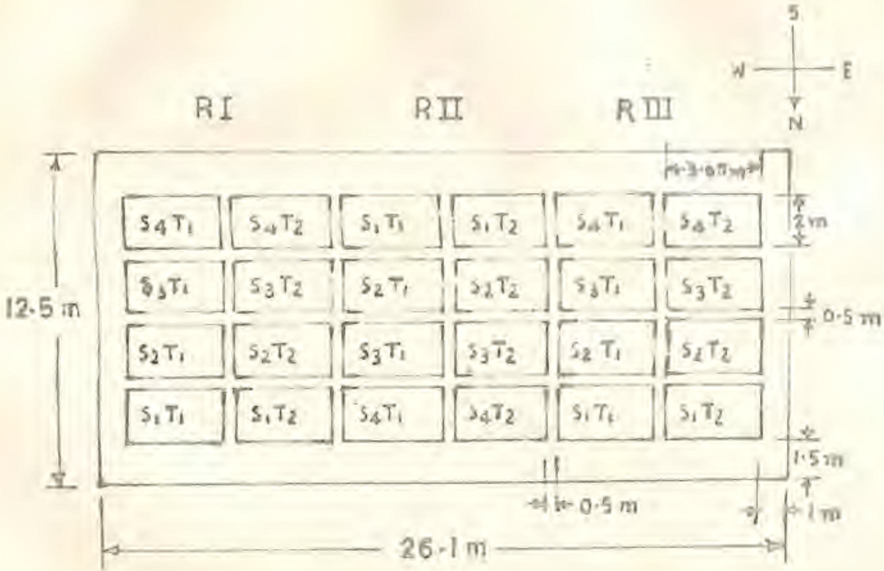
The experimental field was prepared by ploughing once followed by three harrowings. Finally, it was well levelled with the help of leveller.

Layout:

The treatment combinations consisted with staking and nonstaking as main treatments and four spacings as subtreatments were arranged in a split plot design and replicated thrice.

Climate:

Jabalpur comes in semi-arid region having subtropical



S
W
E
N
R I
R II
R III
3.05 m
2 m
12.5 m
0.5 m
1.5 m
0.5 m
1 m
26.1 m
S4 T1
S4 T2
S1 T1
S1 T2
S4 T1
S4 T2
S3 T1
S3 T2
S2 T1
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S3 T1
S3 T2
S2 T1
S2 T2
S3 T1
S3 T2
S2 T1
S2 T2
S1 T1
S1 T2
S4 T1
S4 T2
S1 T1
S1 T2

FIG. 2 - LAY OUT

climate with hot dry summer and cold winter. It is situated at 23.9°N latitude and 79.58°E longitude with an elevation of 411.78 meters above mean sea level. The average annual rainfall of the region is 142.36 cm and the average maximum and minimum temperature are 46.4°C and 4.4°C respectively. The mean annual relative humidity is 78 per cent. The meterological observations during the period of investigation are presented in table 3 and depicted in Fig. 1.

Table 3: The monthly meterological observations recorded at Krishi Nagar Farm, Adhartal, Jabalpur during the crop season.

S.No.	Month and year	Temperature		Relative humidity percent	Rainfall in mm	Rainy days
		Max.	Min.			
1.	July, 1983	31.8	25.1	89.0	304.6	20
2.	August, 1983	30.7	26.6	92.9	316.8	22
3.	September, 1983	30.4	24.0	94.5	604.6	19
4.	October, 1983	29.6	18.6	92.9	62.3	5
5.	November, 1983	26.6	9.0	93.0	-	-
6.	December, 1983	24.9	8.4	91.7	8.4	2
7.	January, 1984	22.7	10.8	93.3	51.1	7
8.	February, 1984	24.4	10.7	89.7	33.1	6
9.	March, 1984	34.8	15.0	67.2	-	-

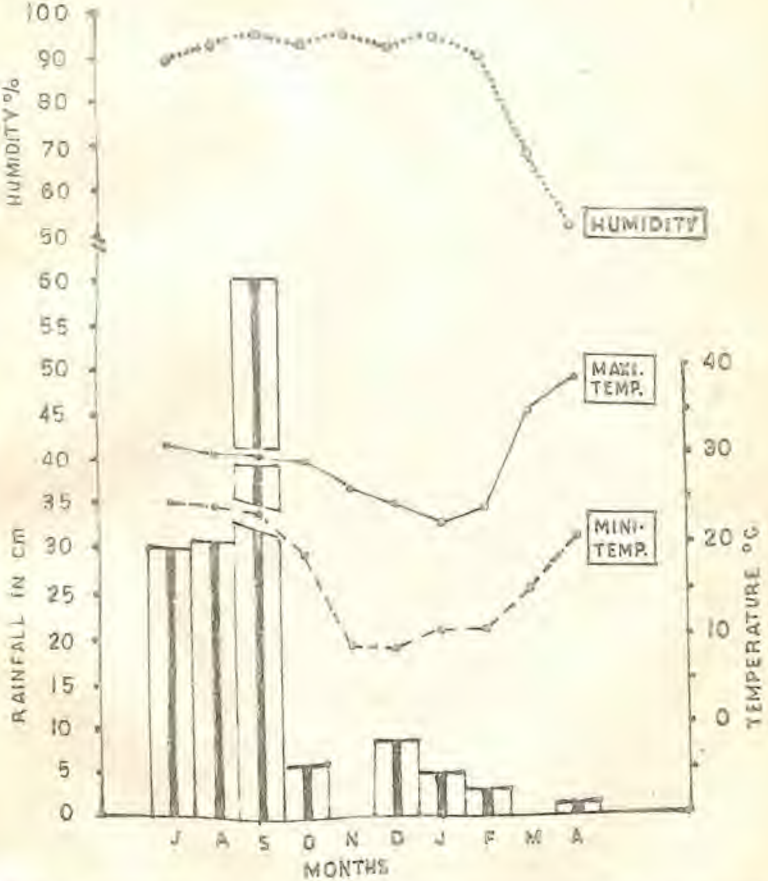


FIG.1 - METEOROLOGICAL OBSERVATIONS UNDER CROP SEASON
(JULY 1983 TO APRIL 1984)

Lay out plan of experiment is depicted in Fig. 2 and other details were as below:

Treatments - 8

(A) Main treatments (2) - Symbols

(1) Staking - T_1

(2) Non-staking - T_2

(B) Sub-treatments (4)

(1) $1.00 \times 1.20 m^2$ - S_1

(2) $1.00 \times 0.90 m^2$ - S_2

(3) $1.00 \times 0.60 m^2$ - S_3

(4) $1.00 \times 0.30 m^2$ - S_4

<u>Other details</u>:

1. Size of net plot - $3.60 \times 2.0 m^2$
2. Gross area under experiment - $326.25 m^2$
3. Net area under experiment - $172.80 m^2$
4. Distance between two replications - 0.5 m
5. Distance between two plots - 0.50 m
6. Irrigation channel - 1.0 m
7. Crop variety - IHR - 4.

<u>Salient features of the variety grown</u>:

Winged bean seed of a variety IHR-4 was brought from Indian Institute of Horticulture Research, Bangalore, in the year 1981 and then multiplied. This variety has white or blue coloured flowers and yellow seeds.

Preparation of ridges:

After lay out of the experiment two ridges of 30 cm width were prepared in each plot at the distance of 1 m. Five kilograms FYM was applied on the ridges of each plot and well mixed with the soil. Uniform dose at the rate of 30 kg.N, 60 kg P_2O_5 and 90 kg K_2O/ha was applied in the form of diammonium phosphate and murate of potash as basal on the ridges just before sowing. Then hills were marked in each plot with the pegs as per intra row spacings under the treatments.

Sowing:

Seeds of winged bean were scarified before sowing with sand paper for improving the germination. Sowing was done on July 8, 1983. Three seeds per hill were dibbled at a depth of 4-5 cm and covered with the soil.

Thinning:

Extra plants by leaving one healthy plant at each hill were removed 40 days after sowing.

Interculture:

Hand weeding followed by hoeing was done at an interval of 15 days in early growth stage and at later stage, weeding was done at an interval of 30 days.

Irrigation:

A light irrigation was given just after sowing for proper germination. During rainy season, crop was irrigated only when it was required. Thereafter, irrigation was given time to time when it was necessary. In all, 12 irrigations were given during the entire period of investigation.

Staking:

Four meters long bamboo sticks were used for staking and 'A' shaped staking was made after 40 days of sowing.

Plant protection measures:

Attack of aphids appeared to be harmful for the crop which was controlled by spraying of Malathion with 0.05% solution on August 8, September 16 and September 22, 1983.

Observations:

Sampling technique: In each plot four plants were tagged for recording observations on various morphological and physiological parameters and finally yield attributing characters.

(A) Growth characters:

(i) Leaves per plant: The number of leaves per plant was counted from the four selected plants at an interval of 45 days and then mean was worked out.

Branches per plant: The number of branches per plant was counted from the ground level up to the growing point of main axis at an interval of 45 days from the above selected plants and then averaged.

Nodes per plant: The total number of nodes were recorded by counting the nodes from the ground level up to the growing point of main axis at an interval of 45 days in each marked plant and average was computed.

Flowers per infloracence: The total number of flowers were noted by counting the pedicels on the peduncle at the time of fifth picking of pods.

Pods per infloracence: The number of pods per inflorance were recorded at fifth picking.

(A) Leaf area:

Leaf area was calculated according to the following formula:

LA = leaf size x number of leaves per plant

Leaf size: Three trifoliate leaves were picked from bottom, middle and top portion of the plant and traced on sheet of paper. Then size was determined by planimeter.

Leaf area index (LAI): Leaf Area Index was calculated according to the following formula:

$$LAI = \frac{\text{Leaf area x number of plants/sq.m.}}{10000}$$

Leaf area duration (LAD): Leaf area duration was calculated according to the following formula:

$$LAD = \frac{A_1 + A_2}{2} (t_2 - t_1)$$

(B) Yield and yield components:

Following observations were recorded at 5th picking.

Pod length: Ten pods were randomly selected from each plot for recording this observation. The length of all 10 pods was measured and then average was calculated.

Girth of pod: The girth of 10 pods already selected for measuring, the length was measured and the average was worked out.

100 ovule weight: Hundred ovules were counted from each treatment and weighed accurately.

Pods per plant: Pods of the four tagged plants were picked up when they attained edible maturity and their number was counted. After this average was computed.

Pods per plot: After harvesting the pods from four tagged plants, pods from the whole plot were harvested in each plot and counted. Number of pods of four tagged plants and each plot was also added in it.

Pod weight per plant: Pods harvested from four tagged plants were weighed. Then average weight of green pods was calculated.

Pod weight per plot: At each picking weight of green pods per plot was recorded (including weight of pods from four selected plants).

Tuber yield per plant: After the last harvest of green pod, tubers were digged out and weight of tubers obtained from four selected plants was recorded for each plot. Then, average tuber yield per plant was worked out.

Tuber yield per plot: After harvesting the tubers from four tagged plants, tubers from the whole plot were harvested plot-wise and weighed. Weight of tubers of four tagged plants was also added with it.

Protein percentage in immature pods and immature tubers:

Representative samples of edible pods and tubers from each plot were taken. First, the samples were dried in sun and later in oven at 60°C till the weight became constant. The dried samples were finely grinded by hand grinder and kept separately in butter paper bags for chemical estimation of nitrogen as per Kjeldahl method.

The protein percentage was calculated with the following formula:

$$= \frac{0.014 \times N \text{ of } H_2SO_4 \times \text{ml of } H_2SO_4 \times 100 \times 6.25}{\text{weight of samples } (0.3 \text{ g})}$$

Statistical analysis:

Statistical analysis of all observations except protein percentage in pods and tuber was done (Cochran and Cox, 1962).

The split plot design permitted analysis of the data by the technique of analysis variance, F test was carried out and significant effects were subjected to calculation of critical differences at 5% and 1% level of significance to judge the differences between the two treatment means.

Correlation studies:

Correlation coefficients are generated to evaluate the inter dependence of variable i.e. pod weight per plot and independent variable, i.e. leaf area index, number of pods, and weight of pods per plant and number of pods per plot. Computation were made according to the Panse and Sukhatme (1954).

$$r_{1.2} = \frac{\text{Cov } 1.2}{\sqrt{\text{var. } 1 \times \text{var. } 2}}$$

where,

$r_{1.2}$ = correlation coefficient

Cov 1.2 = covariance between character 1 and 2.

Var. 1 = variance of character 1

Var. 2 = variance of character 2

...

CHAPTER - IV

RESULTS

The data recorded on different observations in present study were tabulated and statistically analysed. The finding of these observations are briefly described, in this chapter and appropriate tables and appendices are given for the reference.

(A) Morphological parameters:

Leaves per plant: The data presented in table (3) and depicted in Fig. (3) indicate that there was gradual decrease in number of leaves per plant due to the effect of staking and spacing during entire growth period of the crop. The rate of growth was rapid under all the treatments upto 135 days period and after this it became slower. It is also evident from the same table that different treatments had significant effect on this character. (Appendix-1). Higher number of leaves per plant was recorded under wider spacing (S_1) and it decreased significantly with every narrowing of spacings during all growth stages.

The effect of staking in number of leaves per plant was not significant upto 90 days growth stage. After this period, staking produced significantly more leaves per plant than no staking.

Interaction of staking and spacing had marked effect on this character during all growth stages.

Table 3: Mean number of leaves as affected by different treatments during growth period of crop.

Spacing/ treatment	S_1 (1.2m)	S_2 (0.9m)	S_3 (0.6m)	S_4 (0.3m)	Mean
		45 days			
T_1	29.20	25.28	20.12	21.20	23.95
T_2	27.16	24.12	22.95	21.50	23.93
Mean	28.18	24.70	21.53	21.35	
		90 days			
T_1	258.99	253.24	246.45	215.14	243.45
T_2	223.58	199.08	198.37	191.52	202.38
Mean	241.28	226.16	220.91	203.33	
		135 days			
T_1	861.91	808.41	748.58	694.91	778.45
T_2	764.53	665.53	663.33	642.37	683.94
Mean	813.22	736.97	705.95	668.64	
		180 days			
T_1	911.16	872.91	797.45	780.24	840.44
T_2	779.41	749.33	696.45	690.54	728.93
Mean	845.28	811.12	746.95	735.39	

Days	Spacing		Staking		Interaction	
	Sem ±	C.D.5%	Sem ±	C.D. 5%	Sem. ±	C.D. 5%
45	0.476	1.469	0.275	NS	0.874	2.077
90	0.782	2.412	0.261	NS	1.107	3.412
135	1.055	3.253	0.877	5.341	1.492	4.600
180	0.748	2.306	0.523	3.183	1.058	3.261

At 45 days growth stage, staking was found to be superior over non-staking under wider spacings (S_1 and S_2), while non-staking became superior under closer spacings (S_3 and S_4). Moreover, at other growth stages, staking maintained its consistent superiority over non-staking under all the spacings, but the rate of increase in leaves per plant was more under wider spacings as compared with closer spacings.

<u>Nodes per plant:</u> The analysis of variance (Appendix-2) for number of nodes per plant during varying growth period revealed significant differences for spacing, staking as well as their interaction.

The data presented in table (4) indicate that there was gradual decrease in number of nodes per plant due to the effect of spacing up to 180 days growth of the crop. The rate of increase was more rapid under all the treatments upto 135 days period of growth and after this period it became slower. It is also evident from the same table that significantly more number of nodes per plant was observed under wider spacing (S_1) at all growth stages of the crop, and it gradually decreased with every narrowing of spacing. The maximum nodes per plant (307.01) were observed under S_1 at 180 days of growth stage, and minimum nodes (264.44) were recorded under S_4.

Table 4: Mean number of nodes per plant as affected by different treatments during growth period.

Spacing/ Staking	1.0 x 1.20m S_1	1.0x0.9m S_2	1.0x0.6m S_3	1.0x0.3m S_4	Mean
		45 Days			
T_1	11.16	10.62	9.27	8.99	10.01
T_2	11.45	11.58	11.12	10.62	11.19
Mean	11.30	11.10	10.19	9.80	
		90 Days			
T_1	92.75	64.87	62.33	59.66	69.90
T_2	65.95	64.41	57.37	53.04	60.19
Mean	79.35	64.64	59.85	56.35	
		135 days			
T_1	322.95	293.70	282.33	265.94	291.18
T_2	255.33	241.49	223.50	216.49	234.20
Mean	289.14	267.59	252.91	241.11	
		180 days			
T_1	351.99	324.66	313.88	302.41	323.23
T_2	262.04	254.26	231.45	226.48	243.55
Mean	307.01	289.46	272.66	264.44	

Days	Spacing		Staking		Interaction	
	Sem. ±	C.D. 5%	Sem ±	C.D. 5%	Sem ±	C.D. 5%
45	0.128	0.395	0.158	0.966	0.181	0.559
90	0.657	2.025	0.933	NS	0.929	2.864
135	1.192	2.598	0.531	3.234	1.686	3.675
180	1.288	3.969	0.940	5.723	1.821	5.614

Staking has also influenced the number of nodes per plant at all growth stages except at 90 days. The rate of increase in nodes per plant was faster up to 135 days and then it declined. At 45 days stages non staked crop exhibited higher nodes per plant and then it reversed on further growth stages.

All the spacings showed their variable effect on this character at all growth stages under both staked and unstaked crop. At 45 days, the rate of decrease in nodes per plant was much rapid in staked crop than unstaked crop. At 90 days, staked crop showed drastic reduction in nodes with every decrease in spacing while unstaked crop was nearly sense under S_1 and S_2 and these decreased rapidly with further narrowing in spacing. At 135 and 180 days, staked crop resulted greater reduction in nodes per plant with every decrease in spacing comparatively to unstaked plant. Rate of reduction was high between S_1 to S_2 in staked crop and S_2 and S_3 in unstaked crop.

Branches per plant: Mean number of branches per plant under different treatment as shown in table (5) and the graphical representation has been presented in Fig. The analysis of variance is given in the appendix (3).

The data indicated that there was increase in number of branches per plant due to the effect of spacing

Table 5: Mean number of branches per plant as affected by different treatments during growth period

Spacing/ staking	1.0x1.20m S_1	1.0x0.9m S_2	1.0x0.6m S_3	1.0x0.3m S_4	Mean
		45 days			
T_1	3.66	3.04	2.58	2.05	2.83
T_2	2.99	3.16	3.00	2.29	2.86
Mean	3.32	3.10	2.79	2.17	
		90 days			
T_1	35.83	33.24	30.37	27.41	31.71
T_2	32.12	28.53	26.99	25.05	28.17
Mean	33.97	30.88	28.68	26.23	
		135 days			
T_1	121.91	120.12	118.37	116.24	119.16
T_2	113.62	108.04	102.29	98.16	105.52
Mean	117.76	114.08	110.33	107.20	
		180 days			
T_1	143.54	133.66	127.99	125.74	132.73
T_2	124.54	114.70	111.66	109.58	115.12
Mean	134.04	124.18	119.82	117.66	

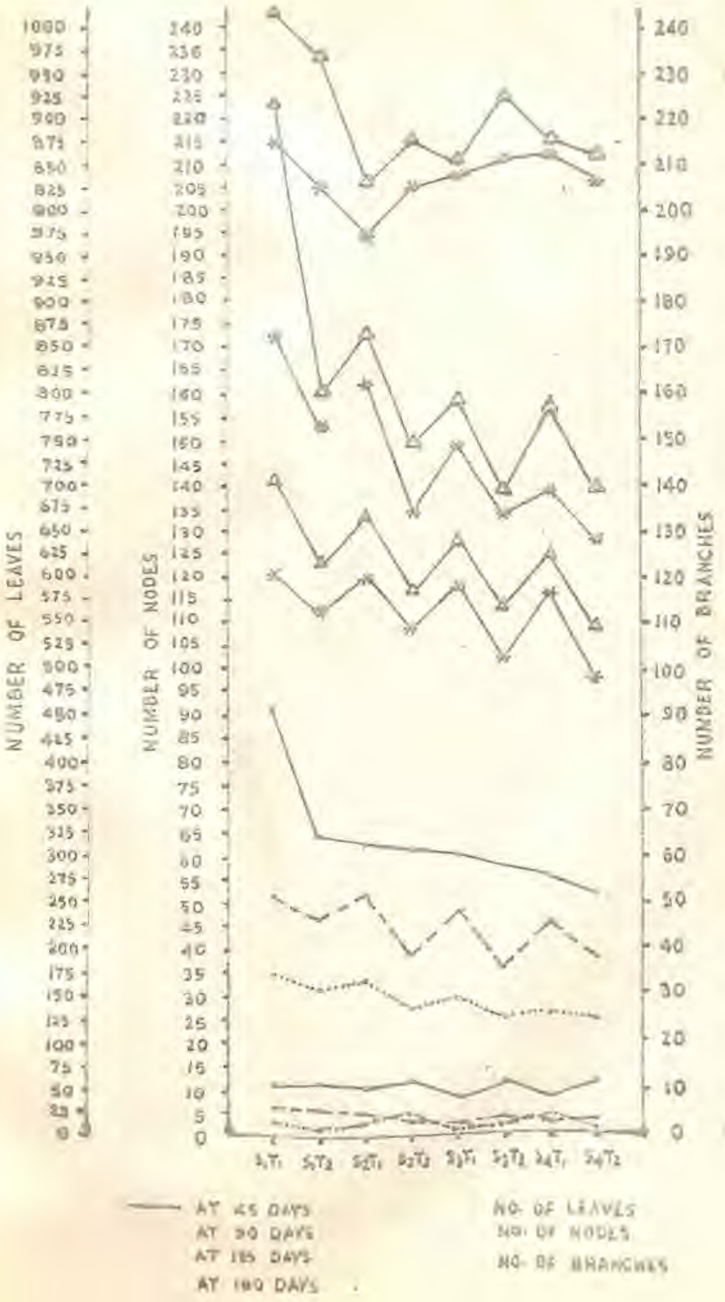
Days	Spacing		Staking		Interaction	
	Sem ±	C.D. 5%	Sem ±	C.D. 5%	Sem. ±	C.D. 5%
45	0.073	0.225	0.05	NS	0.103	0.318
90	0.390	1.202	0.207	1.260	0.551	NS
135	0.540	1.664	0.461	2.809	0.763	2.353
180	0.889	2.740	0.610	3.717	1.259	NS

up to 180 days growth of the crop. The rate of increase was more rapid under all the spacings up to 135 days period of growth and after this it became slower. More number of branches per plant was observed under wider spacings and decreased proportionately at all growth stages up to 180 days with every narrowing of spacing.

As regards, the effect of staking, the number of branches per plant increased significantly upto highest level from 90 days to 180 days growth stage of the crop. Similarly, the effect of staking increased the number of branches per plant up to the highest level and the differences were significant at all the growth stages except at 45 days growth stage. Staking exhibited non-significant effect in all the spacings.

However, interaction of staking and spacing could not influence this character at 90 days and 180 days growth stage of the crop, but the maximum number of branches was recorded in staked crop with wider spacing (1.0 x 1.20 m) at 135 days growth stage. Moreover, the minimum number of nodes per plant was observed in T_1 S_1 (2.05) treatments at 45 days growth stage. The interaction of staking and spacing at 45 and 135 days growth stage was significant in all the spacings which was superior than the non-staked plants at all spacings.

FIG. 3 - EFFECT OF STAKING AND LEVELS OF SPACINGS ON NUMBER OF LEAVES, NUMBER OF NODES AND NUMBER OF BRANCHES PER PLANT



Flowers per inflorescence: The data on number of flowers per inflorescence are presented in table 6 and ANOVA is given in the Appendix (4).

Table 6: Mean number of flowers per inflorescence as affected by staking and different spacings

Spacing/ staking	1.0x1.20m S_1	1.0x0.9m S_2	1.0x0.6m S_3	1.0x0.3m S_3	Mean
T_1	3.93	3.38	2.71	2.05	3.01
T_2	3.58	3.58	3.56	3.06	3.44
Mean	3.75	3.48	3.13	2.55	

	Sem ±	C.D. 5%
T	0.043	0.266
S	0.060	0.186
S x T	0.085	0.263

The data showed in table (6) with regard to flowers per inflorescence were significant under all the spacings and staking. The different spacings influenced the number of flowers per inflorescence apparently with each other. Maximum number of flowers (3.75) per inflorescence was recorded in widest spacings (S_1). Number of flowers per inflorescence was reduced significantly with corresponding decrease in every spacing but S_2 (1.0 x 0.09 m) was at par with S_3 (1.0x0.6m). Number of flowers was per inflorescence influenced by staking. Maximum number of flowers (3.93) was obtained from wider spacing S_1 (1.0 x 1.20) when the plants were staked. However, the lower number of flowers(2.05) per inflorescence was obtained in closest spacing S_3 (1 x 0.6m) when the plants were also staked.

Interaction of staking and spacing has marked effect on this character. Maximum number of flowers per inflorescence (3.93) was recorded in the plants which were staked and sown at wider spacing S_1 (1.0 x 1.20m). Lowest number of flowers per inflorescence (2.05) was recorded at the spacing of (1.0 x 0.3m) and also when the plants were staked (S_4 T_1). The treatment T_1S_1 (3.93) was significantly superior to all the treatment combinations in above table.

Pods per inflorescence: The data on this character are presented in table (7) and ANOVA is given in the Appendix (4).

The data presented in table (7) showed that the different spacings influenced the number of pods per inflorescence apparently with each other. Maximum number of pods (1.78 pods) per inflorescence was recorded under widest spacing (S_1). Number of pods per inflorescence reduced significantly with corresponding decrease in every spacing but S_2 was at par with S_3.

Perusal of data in table (7) revealed that staked plots resulted in significantly higher number of pods

Table 7: Mean number of pods per inflorescence as affected by staking and different spacings

Spacing/ staking	1.0x1.20m S_1	1.0x0.9m S_2	1.0x0.6m S_3	1.0x0.3m S_4	Mean
T_1	2.05	1.68	1.50	1.07	1.57
T_2	1.51	1.08	0.84	0.49	0.98
Mean	1.78	1.38	1.17	0.78	

	Sem ±	C.D. 5%
T	0.012	0.078
S	0.018	0.056
S x T	0.025	0.079

per inflorescence as compared to non-staked plots. Pods per inflorescence were decreased gradually with corresponding decrease in S_2 (1 x 0.9m) which was at par with S_3(1.0x0.6m).

However, interaction of staking and spacing has a marked effect on this character. Maximum number of pods per inflorescence (2.05) was recorded when the plants were staked and sown at wider spacings of 1.0 x 1.20m. Minimum number of pods per inflorescence (0.49) was recorded in the treatment T_2S_4. Treatment T_1S_1 was significantly superior to all other treatment combinations.

Growth Analytical Parameter:

Leaf Area: The data presented in table (8) exhibited that leaf area per plant increased gradually due to the effect of different spacing upto 180 days growth of the crop. The rate of increase was more rapid up to 135 days growth under all the spacings and after this it was slower. It is also evident from the same table that more leaf area per plant was observed under narrow spacings and as the spacing increased the leaf area also decreased correspondingly. The differences in leaf area per plant was significant up to 135 days growth stage in different spacings. Later on, closest spacing (S_4) being at par with spacing (S_3) produced significantly more leaf area than S_1 and S_2 spacings which were almost alike.

All the interactions did not exhibit significant variations in leaf area per plant. Similarly staking also did not influence the leaf area per plant significantly.

Leaf Area Index: The magnitude of LAI varied significantly due to different spacings up to 180 days growth, except at 45 days. The LAI increased rapidly up to 135 days in all the spacings and later on it was slower. The LAI value increased under close spacing, whereas with increased spacing the reduction in LAI

Table 8: Leaf area per plant (cm^2) as affected by different treatments during growth period of crop

Spacing/ staking	1.0x1.20m S_1	1.0x0.9m S_2	1.0x0.6m S_3	1.0x0.3m S_4	Mean
		45 days			
T_1	510.00	760.00	840.00	1520.00	907.50
T_2	600.00	770.00	950.00	1920.00	1060.00
Mean	555.00	765.00	895.00	1720.00	
		90 days			
T_1	17810.00	24610.00	25490.00	40360.00	27067.50
T_2	19650.00	27060.00	28890.00	50840.00	31610.00
Mean	18730.00	25835.00	27190.00	45600.00	
		135 days			
T_1	45950.00	62640.00	65130.00	106070.00	69947.50
T_2	50020.00	69820.00	73800.00	133610.00	81812.50
Mean	47985.00	66230.00	69465.00	119840.00	
		180 days			
T_1	53600.00	72530.00	71250.00	112610.00	77497.50
T_2	57920.00	81440.00	80730.00	141860.00	90487.50
Mean	55760.00	76985.00	75990.00	127235.00	

Days	Spacing		Staking		Interaction	
	Sem ±	C.D. 5%	Sem ±	C.D. 5%	Sem ±	C.D.5%
45	119.286	367.588	78.485	NS	168.695	NS
90	32.977	101.621	20.340	NS	45.636	NS
135	85.992	264.992	53.898	NS	121.611	NS
180	93.009	286.614	56.095	NS	131.534	NS

Table 9: Leaf area Index as affected by different treatments during growth period.

Spacing Staking	1.0x1.20m S_1	1.0x0.9m S_2	1.0x0.6m S_3	1.0x0.3m S_4	Mean
			45 days		
T_1	0.051	0.076	0.084	0.152	0.090
T_2	0.060	0.077	0.095	0.192	0.106
Mean	0.055	0.076	0.089	0.172	
			90 Days		
T_1	1.781	2.461	2.553	4.036	2.707
T_2	1.965	2.706	2.889	5.084	3.161
Mean	1.873	2.583	2.721	4.560	
			135 days		
T_1	4.595	6.264	6.513	10.607	6.994
T_2	5.002	6.982	7.380	13.361	8.181
Mean	4.798	6.623	6.946	11.984	
			180 days		
T_1	5.360	7.253	7.125	11.261	7.749
T_2	5.792	8.144	8.073	14.186	9.048
Mean	5.576	7.698	7.599	12.723	

Days	Spacing		Staking		Interaction	
	Sem ±	C.D. 5%	Sem ±	C.D.5%	Sem ±	C.D.5%
45	0.012	0.039	0.006	NS	0.009	NS
90	0.329	1.015	0.230	NS	0.466	NS
135	0.859	2.649	0.538	NS	1.216	NS
180	0.930	2.866	0.560	NS	1.315	NS

was recorded. Leaf area index increased significantly in nonstaked plants at all growth stages except at 45 days growth stage.

None of the interaction was found significant.

Leaf Area Duration: The data indicated that LAD increased significantly due to the effect of different spacings at all the successive growth stages of crop up to 180 days growth period, except at 45 days stage when it was nearly same due to different spacings. The LAD increased with rapid rate up to 135 days of growth under all the spacings and after this it became slower. Higher magnitude of LAD was recorded under closer spacings and with the increased spacing the LAD decreased correspondingly. The variation in LAD between S_1, S_2 and S_3 spacing were not appreciable at 45 days growth stage. Leaf area duration increased significantly in non-staked plants at all growth stages.

The data given in table (10) indicated that different spacing behaved differently to the staking and non-staking operations at 135 days growth stage of crop.

(C) Yield and yield components:

Pod length (in cm): The data are presented in table (11) and ANOVA is given in the appendix (8).

Table 10: Leaf area duration as affected by different treatments during growth period of crop (m^2 x day)

Spacing/ staking	1.0x1.20m S_1	1.0x0.9m S_2	1.0x0.6m S_3	1.0x0.3m S_4	Mean
		45 days			
T_1	1.149	1.712	1.892	3.435	2.047
T_2	1.366	1.747	2.144	4.329	2.396
Mean	1.257	1.729	2.018	3.881	
		90 days			
T_1	41.237	57.099	59.260	94.253	62.962
T_2	45.594	62.647	67.146	118.732	73.520
Mean	43.415	59.873	63.203	106.492	
		135 days			
T_1	143.489	196.334	305.876	329.482	243.795
T_2	156.779	218.002	231.052	415.042	255.218
Mean	150.134	207.168	268.464	372.262	
		180 days			
T_1	224.017	304.139	306.862	492.037	331.763
T_2	242.879	340.35	347.692	619.822	387.685
Mean	233.448	322.244	327.277	555.929	

Days	Spacing		Staking		Interaction	
	Sem ±	C.D. 5%	Sem ±	C.D.5%	Sem ±	C.D. 5%
45	0.268	0.826	0.178	NS	0.379	NS
90	7.686	23.687	4.757	NS	10.870	NS
135	26.767	82.484	16.704	NS	37.854	NS
180	40.271	124.098	24.747	NS	56.952	NS

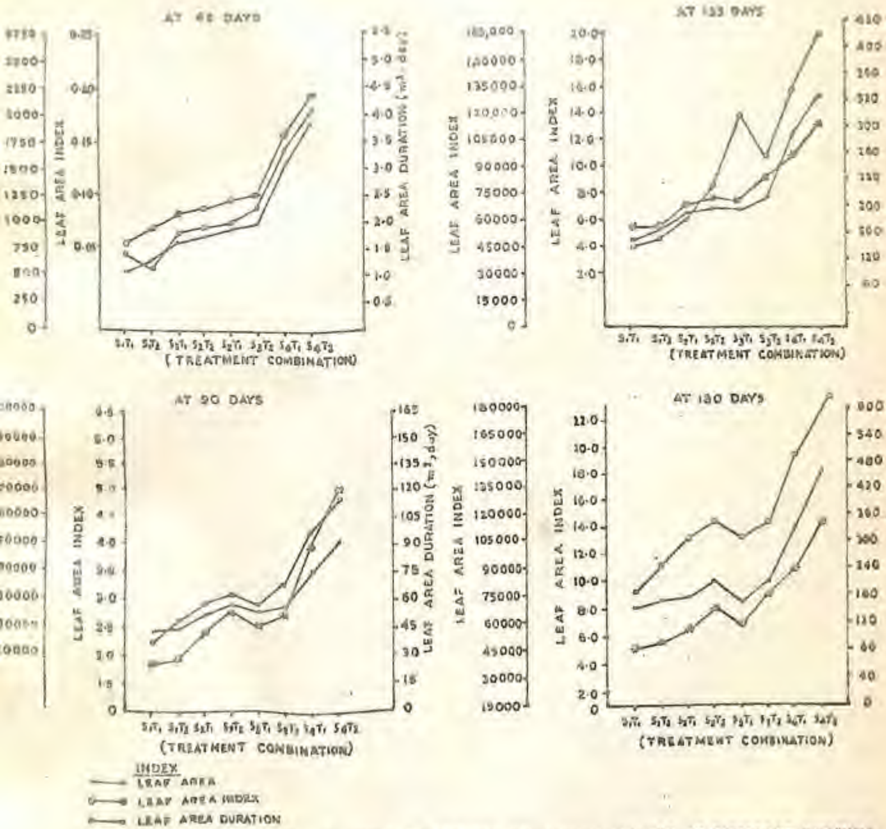


FIG. 4 - EFFECT OF STAKING AND LEVELS OF SPACINGS ON LA, LAI AND LAD AT DIFFERENT INTERVALS

Table 11: Mean pod length as affected by different spacings and staking (cm)

Spacing/ staking	1.0x1.20m S_1	1.0x0.90m S_2	1.0x0.60m S_3	1.0x0.30m S_4	Mean
T_1	18.96	17.87	17.69	16.12	17.66
T_2	19.43	18.94	18.32	15.86	18.13
Mean	19.19	18.40	18.01	15.99	

	Sem ±	C.D. 5%
T	0.100	NS
S	0.123	0.381
S x T	0.175	0.539

It is evident from the data that different spacing influenced the length of pod significantly. Significantly longest pods were obtained in wider spacing S_1 amongst all. The length of pods, reduced significantly with closer spacings.

Staking did not influence the length of pod significantly. However, interaction between spacings and staking practice was found to be significant.

Different spacings exhibited differential behaviour with staking and non-staking practices. Length of pods was superior under non-staking practices to staking under S_1, S_2 and S_3 spacings but the difference was not significant under S_1 while vice-versa under S_4.

Girth of the pod (in cm): The data presented in table (12) and ANOVA given in the appendix (8), revealed that different spacings influenced the girth of pod significantly. Maximum girth of pods (8.44) was observed at the spacing of 1.0x1.20m which was significantly higher to all the spacings. Girth of pod was reduced drastically with every reduction in the spacing and lowest girth (7.35) cm) was found in closest spacing (S_4).

Table 12: Mean pod girth (cm) as affected by different spacings and stakings.

Spacing/ staking	1.0x1.20m S_1	1.0x0.90m S_2	1.0x0.60m S_3	1.0x0.30m S_4	Mean
T_1	8.32	8.07	7.94	7.42	7.94
T_2	8.57	8.07	7.73	7.29	7.91
Mean	8.44	8.07	7.84	7.35	

	Sem ±	C.D. 5%
T	0.088	NS
S	0.054	0.168
S x T	0.077	NS

Staking did not influence the girth of the pod significantly.

None of the interaction exhibited significant variation.

<u>100 ovule weight (in gm)</u>: The data are presented in table (13) and analysis of variance appendix (8) showed significant variation in weight of 100 ovules due to the effect of different spacings, stakings and their interactions as well.

<u>Table 13</u>: Mean 100 ovule weight as affected by different spacings and staking

Spacing/ staking	1.0x1.20m S_1	1.0x0.90m S_2	1.0x0.60m S_3	1.0x0.30m S_4	Mean
T_1	19.83	17.08	16.50	16.50	17.47
T_2	19.25	17.33	15.75	14.91	16.81
Mean	19.54	17.20	16.12	15.70	

	Sem ±	C.D. 5%
T	0.077	0.474
S	0.197	0.608
S x T	0.279	0.860

The data indicate that highest 100 seed weight (19.54 g) was recorded under S_1 which was significantly higher to all other spacings. There was gradual reduction in test weight due to close spacing but, variation between S_3 and S_4 was not distinct.

Staking caused significantly higher test weight over no staking. The test weight showed variable response due to staking vs. non-staking practice under different spacings. Decline trend in test weight was observed with close planting geometry under both staked and unstaked plants but the rate of reduction was markedly higher under closer spacings (S_3 and S_4) in non-staked plants.

Pods per plant: The data presented in table (14) and the graphical representation depicted in Fig. (5) and analysis of variance given in Appendix (9) revealed that different spacings influenced significantly, the pods per plant. While staking practice did not influence it apparently. The interactions were also significant.

The data shown in table (14) indicated the significant reduction in number of pods per plant with every decrease in spacing. The plants with widest spacing (S_1) had the maximum number of pods per plant which was significantly superior to all. Minimum pods per plant were recorded under closest spacing (S_4).

Staking did not influence the number of pods per plant significantly.

The mean pods per plant ranged between 121.80 to 162.49 due to interactions of different spacings and staking.

Table 14: Mean number of pods per plant as affected by different spacings and staking

Spacing/ staking	1.0x1.20m S_1	1.0x0.90m S_2	1.0x0.60m S_3	1.0x0.30m S_4	Mean
T_1	177.11	153.55	137.00	130.61	149.56
T_2	147.88	138.77	128.16	113.00	131.95
Mean	162.49	146.16	132.58	121.80	

	Sem ±	C.D. 5%
SP	4.205	20.489
ST	3.366	NS
SP x ST	5.947	18.328

Under widest spacing (S_1) staking had resulted in maximum pods per plant than nonstaking but both the practice behaved similarly under other spacings. The rate of reduction in pods per plant was higher due to every reduction of spacing in staked plants as compared with unstaked plants.

Pods per plot: The data presented in table (15) and the graphical representation has been plotted in Fig.(5) and ANOVA given in Appendix (9) exhibited that different spacings and staking as well as their interaction influenced the number of pods per plot significantly.

Table 15: Mean number of pods per plot as affected by different spacing and staking

Spacing/ staking	1.0x1.20m S_1	1.0x0.90m S_2	1.0x0.60m S_3	1.0x0.30m S_4	Mean
T_1	1220.88	1113.88	1063.44	986.44	1096.16
T_2	984.88	966.11	919.66	833.33	925.99
Mean	1102.88	1039.99	991.55	909.88	

	Sem ±	C.D. 5%
SP	35.028	138.37
ST	22.739	107.94
SP x ST	49.537	152.65

The data indicated that the maximum number of pods per plot (1102.88)pods) was obtained under widest spacing (S_1) which was significantly higher to all other spacings. Spacing S_2 was next to it being significantly higher to all other spacings. Spacing S_3 and S_4 did not differ significantly in this respect.

Staking also influenced the number of pods per plot. Significantly maximum pods (1096.16) were recorded in staked plot, which were higher over unstaked.

Pods per plot showed differential behaviour under different spacing due to staking and nonstaking operations.

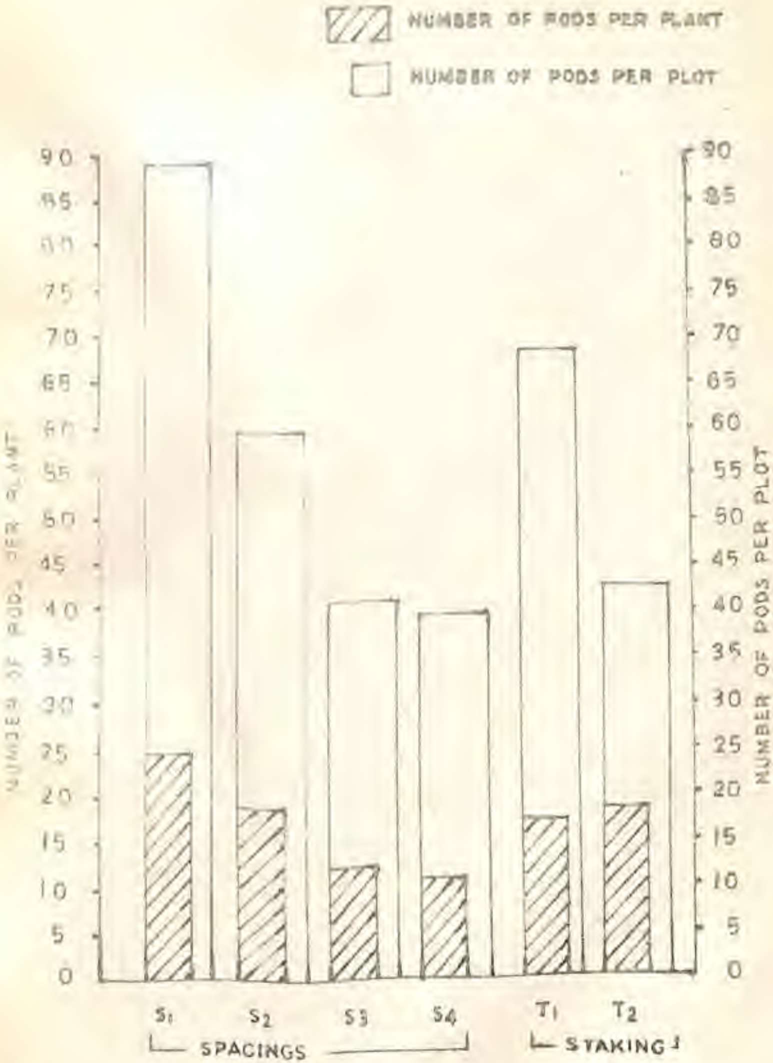


FIG. 5 - EFFECT OF SPACING AND STAKING ON NUMBER OF PODS PER PLANT AND PER PLOT

There were drastic reduction in the pods per plot under nonstaked plot than staked plot due to the effect of spacings.

Weight of pods per plant (in kg): The data presented in table (16) and graphical representation shown in Fig. (6) and analysis of variance Appendix (9) showed that the weight of pods per plant (in kg) was significantly influenced by different spacings. While staking and its interaction with spacing did not show any significant influence.

Table 16: Mean weight of pods per plant (in kg) as affected by different spacings and staking.

Spacing/ staking	1.0x1.20m S_1	1.0x0.90m S_2	1.0x0.60m S_3	1.0x0.30m S_4	Mean
T_1	1.672	1.540	1.431	1.282	1.481
T_2	1.502	1.374	1.263	1.174	1.328
Mean	1.587	1.457	1.347	1.228	

	Sem ±	C.D. 5%
SP	0.046	0.143
ST	0.024	NS
SP x ST	0.065	0.202

The data showed that maximum weight of pods per plant

(1.587) kg) was produced in wider spacing of 1.0x1.2m (S_1) which was significantly higher than the rest. Other spacing like S_2,S_3 and S_4 showed the decreasing trend and differed significantly with each other, except S_3 and S_4 which were at par.

Although staked plants produced higher pod weight per plant than unstaked plants but the differences were not significant, similarly the interaction with varying spacings did not show any significance.

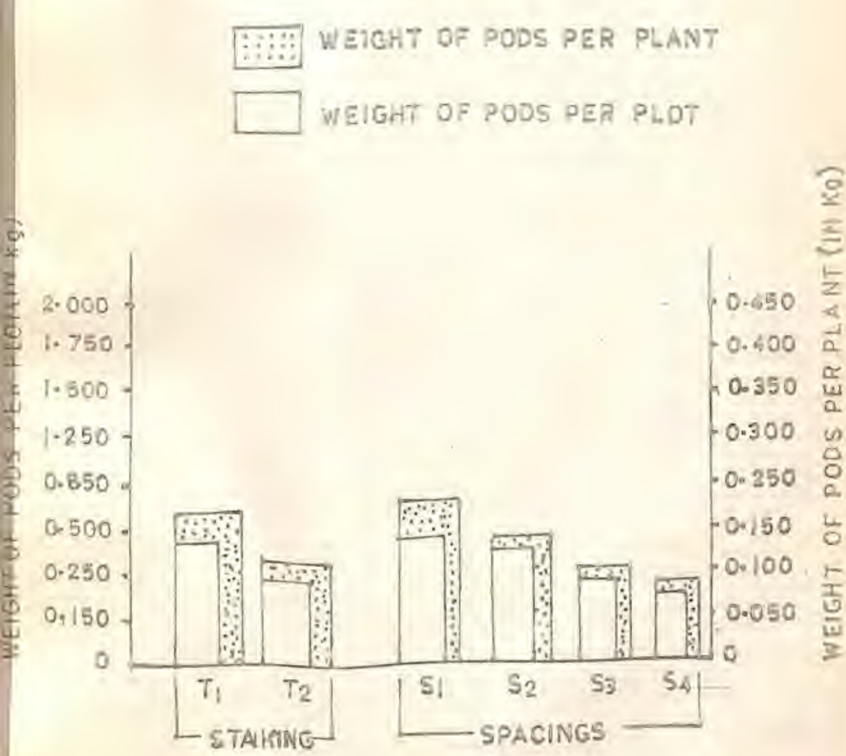
Weight of pods per plot (in kg): The weight of pods per plot was significantly influenced by different spacing and staking as shown in table (17), Fig. (6) and ANOVA in Appendix (9).

Table 17: Mean weight of pods per plot (kg) as influenced by different spacings and staking.

Spacing/ staking	1.0x1.20m S_1	1.00x0.90m S_2	1.0x0.60m S_3	1.0x0.30m S_4	Mean
T_1	11.19	10.36	9.74	9.07	10.09
T_2	9.51	9.15	8.83	7.29	8.69
Mean	10.35	9.75	9.28	8.18	

	Sem ±	C.D. 5%
SP	0.375	1.156
ST	0.030	NS
SP x ST	0.530	1.635

FIG.6 - EFFECT OF STAKING AND SPACINGS ON WEIGHT OF POD PER PLANT AND PER PLOT



The data indicated that the maximum weight of pods per plot (10.35 kg) was obtained under widest spacing (S_1) which was significantly higher to all other spacings. The reduction in pod yield was noted with every decrease in the spacing, however closest spacing (S_4) produced significantly minimum pods per plot (8.18 kg) among all.

Although staking practice resulted in higher pod yield per plot over non-staking but the difference was not significant.

The different spacing behaved differently due to staking and non-staking operation. Under wider spacings (S_1, S_2) staking was found significantly superior over non-staking while both were at par under S_3 spacing. Further reduction in spacing under S_4 (closest spacing) the performance of non-staking became superior though it was not significant.

<u>Tuber yield per plant (in kg)</u>: The data are presented in tables (18), analysis of variance Appendix (9) revealed that different spacing, staking as well as their interactions influenced significantly the tuber yield per plant.

It is clear from the data that highest tuber yield (0.609 kg) per plant was recorded under widest

Table 18: Mean tuber yield per plant as affected by different spacing and staking

Spacing/ staking	1.0x1.20m S_1	1.0x0.9m S_2	1.0x0.6m S_3	1.0x0.3m S_4	Mean
T_1	0.627	0.525	0.474	0.472	0.525
T_2	0.590	0.435	0.392	0.391	0.452
Mean	0.609	0.480	0.433	0.432	

	Sem $\pm$	C.D. 5%
T	0.131	0.789
S	0.115	0.355
S x T	0.171	0.527

spacing (S_1) which was significantly higher to all. Other spacings S_2, S_3 and S_4 showed their decreasing trend in this respect but the differences between them were non-significant.

It is clear from the table that tuber yield per plant increased significantly with the use of staking which was gradually decreased with the narrowing of spacing but it was superior than non-staked plants.

The interaction between staking and spacing was significant.

Tuber yield per plant varied from 391.91 gm to 627.91 gm. The highest tuber yield was obtained in treatment S_1 T_1 followed by S_1 T_2 (590.41 gm). Treatment S_1 T_1 was significantly superior to rest of the treatments. The lowest tuber yield was ob-tained with treatment S_4 T_2 followed by S_3 T_2 (392.83) which was at par with the former treatment.

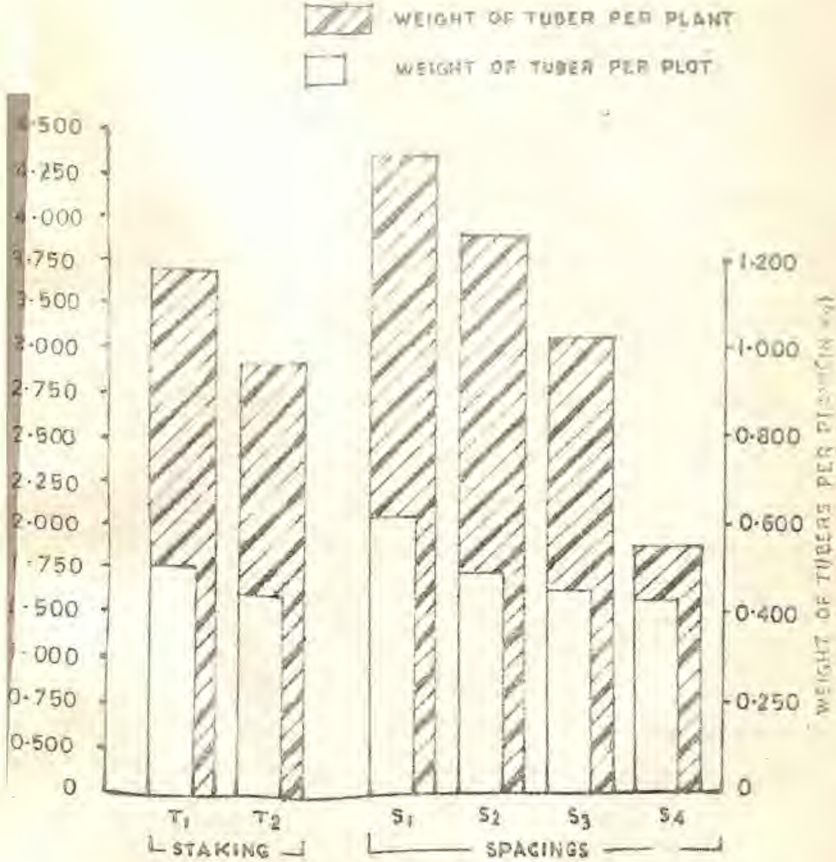
Tuber yield per plot (in kg): The data are presented in table (19), in Fig. (7) and analysis of variance (Appendix-9) exhibited that the tuber yield per plot (in kg) was significantly influenced by different spacing and staking.

Table 19: Mean tuber yield per plot (kg) as affected by different spacings and staking

Spacing/ staking	1.0x1.20m S_1	1.0x0.9m S_2	1.0x0.6m S_3	1.0x0.3m S_4	Mean
T_1	5.136	4.392	3.491	1.925	3.736
T_2	3.429	3.358	2.795	1.816	2.849
Mean	4.282	3.875	3.143	1.870	

	Sem ±	C.D. 5%
T	0.030	0.184
S	0.040	0.125
S x T	0.057	0.177

From the above table (19) it is observed that the maximum yield of tubers per plot (4.282 kg) was



EFFECT OF SPACING AND STAKING ON WEIGHT PER PLANT AND PER PLOT obtained under wider spacing (S_1) which was significantly higher to all other spacings. The tuber yield decreased with decrease in the spacings and closest spacing (S_4) caused significantly lower tuber yield per plot (1.870 kg) over all the spacings. Spacing S_1 was superior to S_2 in this respect but the difference was not remarkable.

It is clear from the same table that tuber yield per plot increased markedly by staking but non-staked plots produced significant reduction in the yield than the staked plots in each spacings.

The tuber yield per plot ranged from 1.816 to 5.136 kg. The highest tuber yield per plot was obtained with treatment S_1 T_1 followed by S_2 T_1 (4.392 kg). Treatment S_1 T_1 was significantly superior to rest of the treatments. The lowest tuber yield per plot was recorded with the treatment S_4 T_2 followed by S_4 T_1 (1.925 kg) which was at par with the former treatment. Similar trend was obtained as in case of tuber yield per plant.

Protein percentage in immature pods:

It is obvious from the data presented in table (20) that maximum and minimum protein contents were recorded from the pods obtained under closest and widest spacing respectively, simultaneously increasing spacing showed decreasing trend of protein content consistantly. There was higher protein content in the pods produced in unstaked plots than staked plots. Highest protein content was found under the S_4 T_2 (closest spacing and nonstaking) amongst all treatments.

Table 20: Mean protein percentage as influenced by different spacings and stakings

Spacing/ staking	1.0x1.2m S_1	1.0x0.9m S_2	1.0x0.6m S_3	1.0x0.3m S_4	Mean
T_1	19.79	20.18	21.89	22.20	21.01
T_2	21.97	23.01	23.80	24.03	23.20
Mean	20.88	21.59	22.84	23.11	

Protein percentage in mature tubers:

The data presented in table (21) indicated that maximum protein percentage was recorded under closest spacings and as the spacing increased the protein percentage decreased. However, the difference was not much. Protein percentage was higher in non-staked crop than staked crop. Amongst the treatment combinations S_4 T_2 had resulted highest protein content in tubers.

The result given in table (22) indicate that number of pods per plant, number of pods per plot, weight of pods/plant and 100 seed weight, length and girth of the pods were positively correlated with pod yield per plot. Amongst these characters number of pods per plot as well as per plant were only reach the level of

Table 21: Mean protein percentage as influenced by different spacings and stakings

Spacing/ staking	1.0x1.2m S_1	1.0x0.9m S_2	1.0x0.6m S_3	1.0x0.3m S_4	Mean
T_1	7.09	7.53	7.97	8.02	7.65
T_2	7.49	7.88	8.32	9.30	8.24
Mean	7.29	7.70	8.14	8.66	

Table 22: Correlation coefficient between yield of pod per plot with others yield components under different treatments

S.No.	Characters	Correlation coefficient
1.	No. of pods per plant	+ 0.56975
2.	No. of pods per plot	+ 0.96716**
3.	Weight of pods/plant	+ 0.97843**
4.	Tuber yield/plant	- 0.71890
5.	Tuber yield per plot	- 0.84567*
6.	100 seed weight	+ 0.36247
7.	Length of the pod	+ 0.7901
8.	Girth of the pod	+ 0.3213

* Significant at 5% level

** Significant at 1% level

significance strongly. Tuber yield/plant and tuber yield/plot showed their negative relationship. Among these two, tuber yield per plot exhibited its significant association.

Pod yield per plot (kg per ha):

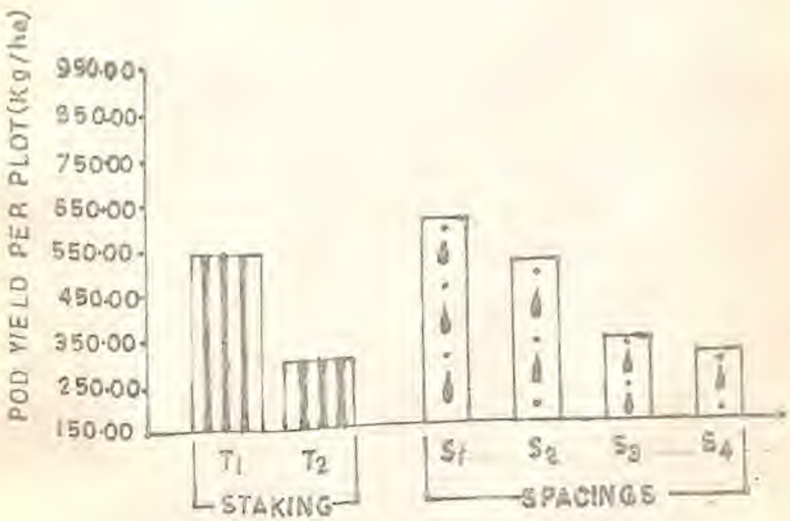
The data are presented in table (23) in Fig. (8), exhibited that the pod yield per plot (kg/ha) was significantly influenced by different spacing and staking.

Table 23: Mean weight of pods per plot (kg/ha) as influenced by different spacings and staking

Spacing/ staking	1.0x1.2 m S_1	1.0x0.90m S_2	1.0x0.60m S_3	1.0x0.30m S_4	Mean
T_1	15541.66	14388.88	13527.77	12597.22	14013.88
T_2	13208.33	12708.33	12263.88	10125.00	12076.38
Mean	14374.99	13548.60	12895.82	11361.11	

	Sem ±	C.D. 5%
SP	63.46	195.56
ST	51.06	310.74
SP x ST	115.22	355.06

FIG.8 - MEAN WEIGHT OF PODS PER PLOT (kg/ha) AS INFLUENCED BY DIFFERENT SPACING AND STAKING



The data indicated that the maximum weight of pods per plot (14374.99) was obtained under widest spacing (S_1) which was significantly higher to all other spacing, however closest spacing (S_4) produced significantly minimum pods per plot (11361.11 kg/ha) among all. Although staking practice resulted significantly higher pod yield (kg/ha) over non-staking.

Interaction(S_1 T_1) gives maximum yield (15541.66 kg) followed by S_2 T_1 (14388.88 kg). These two interactions performs significantly better than other remaining interactions. Interaction S_4 T_1 (10125.00 kg) gives significantly minimum yield as comparedto remaining interactions.

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CHAPTER - V

D I S C U S S I O N

Planting density and staking promote variation in the growth pattern of the plants which can be one of the means of increasing the productivity per unit area. Being highly proteinous crop and having multi-useful parts the present study was done to find some useful information, on the behaviour, growth and development, yield and quality of winged bean as affected by different spacing and staking. The results obtained during the investigation have been discussed and interpreted in this chapter.

Seasonal effect:

The growth and the performance of the crop was satisfactory from the initial stage of crop to final stage. There was comparatively high temperature after middle of September to October due to early set of monsoon which restricted the need of irrigation to the crop. High temperature caused the plant to spend more energy for respiration and other physiological activities resulting in low, net photosynthetic rate, consequently, the growth and yield characters were adversely affected.

Morphological parameters:

Results indicated that the number of leaves per plant was increased rapidly upto 135 days growth stage of the crop and after this the rate of incrëase showed a decline trend. Different spacings affected the number of leaves per plant significantly but the variation was not much up to 90 days growth period and after this widely spaced crop had more number of leaves per plant than narrow ones. Individual plant of widely spaced crop got opportunity to utilize more space, light, nutrients and water which probably resulted in good growth of crop and consequently, high number of leaves per plant. Lenka (1966) has also reported gradual increase in the number of leaves per plant as row spacing was brought wide in pea crop . Number of leaves was significantly increased by staking at all growth stages, as compared to non-staking crop plant.

The possible reasons for higher number of leaves under staked plant may be due to the luxurious growth of the crop which exposed to maximum radiation with staking. Adelana (1976) has also observed more number of leaves per plant due to staking in tomato plants variety, pusa Early Dwarf.

Number of nodes per plant was increased rapidly up to 135 days growth stage of the crop and after this the rate of increase showed a decline trend. Different spacings affected the number of nodes per plant significantly, widely spaced crop had more number of nodes per plant than narrow ones. Individual plant of widely spaced crop got opportunity to utilize more space, light nutrients and water which may probably be stimulated the growth of the crop and consequently, high number of nodes per plant. Bennett *et al.* (1977) observed that nodes per plant, were significantly higher in wide spacing. He also concluded that a bean ideotype for temperate zone monoculture should have a high number of nodes per branch in bean. Number of nodes was significantly increased at all growth stages due to staking, as compared to non-staked plant. The possible explanation for higher number of nodes under staking may be due to better aeration, light and luxuriant growth of the crop. Bennett (1977) has also reported that semi-climbing bean (*Phaseolus vulgaris* L.) for temperate zone monoculture should have a high number of nodes per plant in wider spacing.

Number of branches per plant increased rapidly up to 135 days growth stage of the crop and after this the rate of increase showed a decline trend. Different spacings affected the number of branches per plant significantly and widely spaced plants had more number of branches than narrow spaced. Individual plant of widely spaced crop got opportunity to utilize more space, light, nutrients and water which may probably be resulted in good growth of crop and caused increased number of branches per plant. Bennett *et al.* (1977) observed that branches per plant were significantly increased in higher density and concluded that a bean ideotype for temperate zone monoculture should have a high number of branches per plant in bean. Number of branches was significantly increased with staking at all growth stages as compared to non-staked plant. Kueneman and Waklace (1978) has studied the climbing type of growth habits in large type bean (<u>Phaseolus</u> <u>vulgaris</u>).

Number of flowers per inflorescence was significantly influenced due to different treatments. Significantly higher number of flowers per inflorescence was noticed under widely spaced plant as compared with narrow planted one. Better utilization of light air and nutrient may be the possible reasons for increased initation of flowers under widely spaced plant. However, non-staked plants significantly stimulated more flowers, than the staked one but the variations between two treatments were not large, which indicated that non-staking treatment to some extent was beneficial for flower initiation. However, number of pods per inflorescence was noticed under wide spaced plant as compared with narrow planted one. Better utilization of light and nutrients may be the possible reason for more setting of pods under widely spaced crop. Staked crop caused significantly better setting of pods than non-staked. Results also revealed that decreasing level of spacings decreased number of pods per inflorescence in staked plant.

Physiological parameters:

The results of present investigation indicated that leaf area of winged been was significantly influenced by different spacings and staking. Rapid increase in leaf area under all the treatments up to 180 days growth period of crop was noted. It was more under narrowly spaced plants than widely ones. More luxuriant vegetative growth due to large number of leaves was observed under narrow spacing, resulting in higher leaf area per plant. Moreover staking did not influence the leaf area as compared to control (non-staked). Non-staking treatment could maintain high humidity, CO_2 concentration and less exposure to hot wind in greater meristematic activities of cells and consequently the large size leaves of plant. Similar result was reported by Basia (1973) and Sharma (1973) in soybean and Dolichos lab lab.

The leaf area index was highest under closest spacings, and minimum in widest spacing. This may be because of variation in plant population in unit area. More population under closer spacing in responsible for higher LAI. The results are in accordance with findings of Weber et al. (1966), Reddy and Singh (1976) in soybean crop. Leaf area index was not affected due to staking. The leaf area duration was highest under the closest spacing and minimum in widest spacing. This may be because of variation in plant population and interval between two growth stage of the crop in unit area. More population under closer spacing is responsible for higher LAD. The results are in accordance with findings of Weber *et al*. (1966), Reddy and Singh (1976) in soybean. The staking did not influence the LAD.

Yield and yield components:

Higher yield per unit area is the prime objective of research and yield is mainly affected by genetical as well as various environmental factors. Environmental factors include not only the natural factors but also the cultural manipulations in cultivation of the crops. Plant population is one of the important factors influencing the productivity of any crop. Plant population can be manipulated by planting the crop with different spacings. Plant density becomes more or less with decrease and increase in spacings respectively. With increase in the plant population per unit area of land, the yield also increased up to a certain limit but further increase in the plant population decreased the yield. Although individual plant under wider spacing resulted in increased yield attributes and more yield to compensate the loss in yield due to less plant density under wider spacing is of great significant. After optimum plant population, use of staking is helpful for boosting up the productivity.

The present investigation indicated that different spacing had significant effect on various yield attributing characters like pod length, pod girth and 100 ovule weight which proves that this crop has better wide adoptability under varying environmental conditions. Several workers have also reported the similar findings in other crops which resembles morphologically to winged bean. Ezodima (1974) reported increased grain yield per plant of cowpea under wider plant population. Reddy and Singh (1976) found that the seed weight of soybean decreased significantly with increase in plant population. Rojas et al. (1977) reported significant effect of spacing on seed weight in beans. However, staking had no significant effect on length and girth of the pod but 100 seed weight was influenced significantly due to the staking as compared to non-stated plants. Pandey et al. (1981) emphasised that 100 seed weight is the most important sink parameter which had positive correlation with seed yield in cowpea.

The present findings thus indicate that the number and weight of pods per plant was highest under widest spacing and gradually reduced with the increase in plant population. The possible reason for better performance of plants of winged bean under wider spacing may be that widely spaced plants got large area for the up take of nutrients and moisture which resulted in better growth. Simultaneously, leaves of such plants are large in size and utilize more solar radiation and thus can assimilate more photosynthates and thus consequently plants of widely spaced crop produced greater number of pods, while in closer spacing, there was more competition in between the plants for nutrition and utilization of solar energy. The results are in agreement with the findings of Veeraswamy and Rathnaswamy (1974) who observed that wider spacing increased number of pods as well as seed yield per plant in soybean. Similarly, Badillo <u>et al</u>. (1978) reported that pod number and pod weight were greatest under widely planted <u>Phaseolus vulgaris</u>. However, staking did not influence significantly the number of pods and weight of pods per plant. On the contrary, the number and weight of pods per plot was significantly better under widest spacings amongst all. The number and weight of pods per plot decreased correspondingly with every decrease in spacing. Although, the individual plant of wider spacing had superior yield attribute comparatively to closely spaced plants, but staked plant under wider spacing ultimately resulted in greater number and weight of pods per unit area. This may be the possible cause for higher number and weight of pods per plot. Similar results were reported by Wurater and Nga Nga (1971), Quinn (1974), Adelana (1976) in tomato. Spaeing and staking were found to be significant in respect of number of pods per plant. Different spacing showed their differential response to the staking on this account. The rate of increase in number of pods per plant was higher by staking under widest spacing (1.0 x 1.20 sq.m.) than other spacings. Spacing of 1.0 x 1.20 m resulted the maximum number and weight of pods per plot. Similar results were reported by several workers, Bordia *et al.* (1977), Goulden (1977), Rajewar and Patil (1979), Kuememan *et al.* (1978) in tomato and bean.

Maximum tuber productivity per plant and per plot was recorded under widest spacing and get reduced correspondingly with the increase in plant population per unit area. The better development of individual tuber, could be due to faster growth and development of plants under widely spaced condition. On the other hand, in close plants there might have been more competition amongst plants for water, nutrients, space and light which might have affected the growth. Significantly higher tuber yield per plot was noted due to staking over non-staked plants, which may be due to increased exposure to light, aeration and faster translocation of photosynthates. The reasons for poor tuber yield under non-staked crop plants may be as a result of regular maintenance of vegetative growth results due to sensescence of shaded leaves without giving any change for the formation of tuber.

The combination of spacing and staking was found to be significant in respect of tuber yield per plant and per plot. The maximum yield was recorded with the combination of wider spacing and staking (S_1 T_1). The tuber yield was lowest under narrowest spacing and non-staked crop plants (S_4 T_2).

Similar results were reported by Kesavan and Korachan (1973) and Merinov (1973) in soybean, Edje <u>et al</u>. (1975) in dry beans and Rhodes (1978) in cowpea.

Moreover, the protein percentage was higher in non-staked crop than staked crops. Amongst the treatment combination S_4 T_2 had resulted in highest protein content in tubers. From the results, it appears that pod yield per plot had positive correlation with number of pods per plant, number of pods per plot and weight of pods per plant under staking, exhibited positive association with 100 ovule weight, length and girth of the pod. However, in different spacings the tuber yield per plant and tuber yield per plot had negative relationship with pod yield per plot. Similar results were also reported by Bordia *et al.* (1977), Rajas *et al.* (1977), Singh *et al.* (1977), Pandey *et al.* (1981) in cowpea, Patel (1973) in cowpea.

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CHAPTER - VI

SUMMARY, CONCLUSIONS AND SUGGESTIONS FOR FURTHER WORK

The present investigation entitled "Effect of spacings and staking on growth and yield of winged bean (Psophocarpus tetragonolobus (L.) D.C.) was carried out during 1983-84 at Vegetable Research and Instructional Farm, Maharajpur, Department of Horticulture, J.N.K.V.V., Jabalpur. The experiment was laid out in split-plot design arranging staking and non-staking as main treatments and combination of four spacings, viz., 1.0 x 1.20 m^2, 1.0 x 0.90 m^2, 1.0 x 0.60 m^2 and 1.0 x 0.30 m^2 as subtreatments. All possible treatment combinations were replicated thrice. Sowing of IHR-4 cultivar of winged bean was done on the 8th July, 1983, in Sandy loam soil of experimental area. The findings of investigation were as under:

The number of leaves per plant was increased during entire growth period of crop under all treatments but the rate of increase was faster up to 135 days only. Higher number of leaves per plant was noticed under wider spacings than narrow spacing. Increased number of leaves per plant was recorded with staked plots than unstaked plots of these treatments.

It was remarkable that nodes was induced late in winged bean under wide spaced crop than narrow ones.

On the other hand the crop was influenced with staking than control.

Number of branches per plant was affected by any of the treatments. More branches per plant was obtained from wider spacing. The number of branches increased significantly up to the highest level from 90 days to 180 days growth stage of the crop.

Number of flowers per inflorescence was influenced by the spacings and as well as by staking. But more number of flowers resulted in non-staked plots with wider spacing, setting of pods per inflorescence was superior under wider spacing. However, staked plots resulted in significantly higher number of pods per inflorescence as compared to non-staked plots.

Leaf area, leaf area duration and leaf area index of winged bean was significantly influenced due to the effect of different spacings. These parameters increased rapidly under all the spacings up to 132 days growth period of crop though the gradual increase was observed up to 180 days growth stage. These parameters were superior with narrow spaced plant than wider ones. Staking did not cause such effect on LA, LAD and LAI.

There was significant effect of different spacings and staking as well as their interaction on different yield attributing characters, such as pod length and 100 ovule weight but girth of pod was influenced significantly under wide spaced crop than narrow ones. Pod length was superior under wider spacings and girth of pod was also superior under wider spaced crop 100 ovule weight was more under widely spaced crop than narrow ones. Staking was also influenced significantly than non-staked crop plots. The number and weight of pods per plant were highest under widest spacing and correspondingly reduced with every closening of spacings, up to closest. The wider spacing (1.0 x 1.20 m^2) produced significantly higher the number and weight of pods per plot and with every narrowing in spacings they started to be reduced. This indicates that higher plant density per unit area is more responsible for increasing the yield upto a certain limit. Pods per plot was influenced by the staking but number of pods and weight of pods per plant and per plot and weight of pods per plots did not influenced by the staking. Combination of wide spacing (1.0 x 1.20 m^2), staking produced the maximum pod yield per plot.

Maximum tuber yield per plant and per plot was recorded under widest spacing and it reduced correspondingly with every narrowing of spacings. Tuber yield per plant and per plot was significantly higher due to the effect of staking than non-staked crop plants.

Protein percentage of immature and mature tubers decreased with increased in spacings but non-staked crop increased the protein percentage of immature pods and mature tubers.

The results are concluded in brief as under:

1. Sowing of winged bean at the spacing of 1.0 x 1.20 m^2 gave more green pods per unit area.
2. Application of staking resulted in better growth and yield of winged bean.
3. 1.0 x 1.20 m^2 spacing, and staking proved useful for increasing the yield per unit area.
4. Protein content in immature pods and mature tubers increased with narrow spacing and in non-staked crop plant, respectively.
5. Higher protein content in immature pods and mature tubers was recorded under close spacing.

SUGGESTIONS FOR FURTHER WORK

1. This experiment should be repeated to find out the consistency in the results.

2. Different methods and technique of staking should be studied.

3. Effect of different micro nutrients should also be studied along with the varying levels of spacings.

4. Sowing in other planting geometries like square planting vs. rectangular planting patterns should also be compared under different plant densities.

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APPENDICES

TABLE OF ANALYSIS OF VARIANCE

Table 1: Mean sum of squares of different parameters - leaves per plant at 45 days interval

Source of variation	d.f.	Mean sum of squares				'F' value at 5%
		45	90	135	180	
Replication	2	0.1490	77.626	25.45	4.835	19.00
Main treatment (ST)	1	0.0016	10121.695	53595.85*	74606.38*	18.51
Error (a)	2	0.9095	0.8195	9.245	3.285	-
Sub-treatment (SP)	3	62.145*	1471.011*	22624.84*	16449.347*	3.49
Interaction (ST x SP)	3	6.107*	304.07*	2097.503*	570.8*	3.49
Error (b)	12	1.364	3.678	6.687	3.361	-
Total	23					

Table 2: Nodes per plant at 45 days interval

Source of variation	d.f.	Mean sum of squares				'F' value at 5%
		45	90	135	180	
Replication	2	0.051	7.88	17.838	6.341	19.00
Main treatment	1	6.243*	119.304	19479.202*	38071.939*	18.51
Error (a)	2	0.303	10.462	3.391	10.614	-
Sub-treatment	3	0.711*	205.428*	2569.476*	2134.517*	3.49
Interaction (M x S)	3	0.434*	11.545*	99.598*	106.30*	3.49
Error (b)	12	0.099	2.592	8.534	9.958	-
Total	23					

Table 3: Branches per plant at 45 days interval

Source of variation	d.f.	Mean sum of squares				'F' value of 5%
		45	90	135	180	
Replication	2	0.244	0.296	6.253	10.151	19.00
Main treatment	1	0.005	75.119*	1115.483*	1861.381*	18.51
Error (a)	2	0.030	0.515	2.557	4.479	-
Sub-treatment	3	1.514*	65.029*	125.829*	316.650*	3.49
Interaction (M x S)	3	0.347*	1.408	28.365*	3.741	3.39
Error (b)	12	0.032	0.914	1.750	4.746	-
Total	23					

Table 4: Flowers per inflorescence and pod per inflorescence

Source of variation	d.f.	Mean sum of squares		'F' value at 5%
		Flower per inflorescence	Pods per inflorescence	
Replication	2	0.041	0.024	19.00
Main treatment	1	1.097*	1.882*	18.51
Error (a)	2	0.023	0.002	-
Sub-treatment	3	1.601*	1.189*	3.49
Interaction (M x S)	3	0.593*	0.014*	3.49
Error (b)	12	0.022	0.002	-
Total	23			

Table 5: Leaf area per plant at 45 days interval (sq.m.)

Source of variation	d.f.	Mean sum of squares				'F' value at 5%
		45	90	135	180	
Replication	2	13445.00	860.00	6110.00	6730.00	19.00
Main treatment	1	144520.00	12370.00	84450.00	101250.00	18.51
Error (a)	2	78815.00	4965.00	34860.00	37760.00	-
Sub-treatment	3	1566270.00*	73726.667*	535953.33*	511460.00*	3.49
Interaction (M x S)	3	41533.333	7453.333	49980.00	62933.333	3.49
Error (b)	12	85375.00	6525.00	44368.333	51904.167	-
Total	23					

Table 6: Leaf area index per plant at 45 days interval (sq.m.)

Source of variation	d.f.	Mean sum of squares				'F' value at 5%
		45	90	135	180	
Replication	2	0.00005	0.086	0.611	0.673	19.00
Main treatment	1	0.001	1.237	8.445	10.125	18.51
Error (a)	2	0.005	0.497	3.486	3.776	-
Sub-treatment	3	0.0151*	7.372*	56.899*	55.596*	3.49
Interaction (M x S)	3	0.006	0.745	1.694	1.842	3.49
Error (b)	12	0.001	0.652	4.436	5.190	-
Total	23					

Table 7: Leaf area duration per plant at 45 days interval (sq.m.)

Source of variation	d.f.	Mean sum of squares				'F' value at 5%
		45	90	135	180	
Replication	2	0.068	47.178	585.5	1299.210	19.00
Sub-treatment	1	0.731	670.038	8175.48	18763.461	18.51
Error (b)	2	0.384	271.660	3348.655	7349.262	-
Sub-treatment	3	7.718*	4349.759*	54223.957*	113799.42*	3.49
Interaction (M x S)	3	0.423	132.243	1626.28	3577.033	3.49
Error (b)	12	0.432	354.514	4298.879	9730.675	-
Total	23					

Table 8: Yield and yield components

Source of variation	d.f.	Mean sum of squares			'F' value at 5%
		Length of pod (cm)	Girth of pod (cm)	100 ovule weight (g)	
Replication	2	0.077	0.585	0.541	19.00
Main treatment	1	1.354	0.003	2.667*	18.51
Error (a)	2	0.122	0.093	0.073	-
Sub-treatment	3	11.176*	1.240*	17.705*	3.49
Interaction (M x S)	3	0.459*	0.061	0.847	3.49
Error (b)	12	0.092	0.018	0.234	-
Total	23				

Table 9: *Yield and yield components*

Source of variation	d.f.	No. of pods per plant	No. of pods per plot	Weight of pods per plant (kg)	Weight of pods per plot (kg)	Tuber yield per plant (kg)	Tuber yield per plot (kg)	'F' value at 5%
Replication	2	45.18	29791.65	0.022	0.214	0.21	0.009	19.00
Main treatment	1	2448.468	140141.70*	0.139	0.205	31.49*	4.714*	18.51
Error (a)	2	136.036	6204.81	0.007	0.011	0.20	0.011	-
Sub-treatment	3	3324.69*	268730.5*	0.258*	15.253*	41.56*	6.725*	8.49
Interaction	3	331.025*	23151.13*	0.054*	2.975*	0.83*	0.669*	3.49
Error (b)	12	106.129	7361.86	0.013	0.845	0.08	0.010	-
Total	23							

* Significant at 5% level

** Significant at 1% level

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* Originals not seen.

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